CHAPTER II - RECONNAISSANCE AND FIXES

1. GENERAL

The Joint Typhoon Warning Center depends on reconnaissance to provide necessary, accurate, and timely meteorological information in support of each warning. JTWC relies primarily on three reconnaissance platforms: aircraft, satellite, and radar. In data rich areas, synoptic data are also used to supplement the above. Optimum utilization of all available reconnaissance resources is obtained through the Selective Reconnaissance Program (SRP); various factors are considered in selecting a specific reconnaissance platform including capabilities and limitations, and the tropical cyclone's threat to life and property both afloat and ashore. A summary of reconnaissance fixes received during 1987 is included in Section 6 of this chapter.

2. RECONNAISSANCE AVAILABILITY

a. Aircraft

Aircraft weather reconnaissance for JTWC was performed by the 54th Weather Reconnaissance Squadron (54th WRS) located at Andersen Air Force Base, Guam. Due to budgetary decisions, 1987 was the final year for dedicated weather reconnaissance in the western North Pacific. The 54th WRS was deactivated effective 1 October 1987. The phaseout of aircraft and personnel began well before the actual deactivation of the squadron and effected aircraft availability from the very beginning of the tropical cyclone season. Only four aircraft were on station at the start of the year, three of which were storm-capable. One storm-capable aircraft was transferred to Keesler Air Force Base, Mississippi on 15 July leaving just two capable airframes to fly reconnaissance missions up to the date of deactivation. The shortage of both aircraft and personnel significantly limited the number of reconnaissance missions that the 54th WRS was able to fly throughout the season until closure. The JTWC aircraft reconnaissance requirements were provided daily to the Tropical Cyclone Aircraft Reconnaissance Coordinator (TCARC). The TCARC then married the tasking from JTWC with the available airframes from the 54th WRS.

As in the previous years, aircraft reconnaissance provided direct measurements of standard pressure-level heights, temperatures, flight-level winds, sea-level pressures, estimated surface winds and numerous additional parameters. The meteorological data were gathered by the Aerial Reconnaissance Weather Officer and dropsonde operators from Detachment 3, 1st Weather Wing who flew with the 54th WRS. These data provided the Typhoon Duty Officer with indications of changing tropical cyclone characteristics, radii of associated winds and current tropical cyclone position and intensity. Another important aspect was the availability of the data for research on tropical cyclone analysis and forecasting.

b. Satellite

Satellite fixes from USAF/USN ground sites and USN ships provide day and night coverage in JTWC's area of responsibility. Interpretation of this satellite imagery provides tropical cyclone positions and estimates of current and forecast intensities through the Dvorak technique.

c. Radar

Land-based radar provides positioning data on well-developed tropical cyclones when in the proximity (usually within 175 nm (324 km)) of the radar sites in the Philippines, Taiwan, Hong Kong, Japan, South Korea, Kwajalein, and Guam.

d. Synoptic

JTWC also determines tropical cyclone positions based on the analysis of the surface/gradient-level synoptic data. These positions were helpful in situations where the vertical structure of the tropical cyclone was weak or accurate surface positions from aircraft or satellite were not available.

TABLE 2-1. AIRCRAFT RECONNAISSANCE EFFECTIVENESS

MISSIONS	TASKED	COMPLETED	MISSED	PERCENT
FIXES	68	57	11	82.9%
INVESTS	20	16	4	76.6%
SYNOPTIC TRACKS	8	7	1	87.5%

MISSION EFFECTIVENESS GRADING

	TOTAL	PERCENT
FIX MISSIONS TASKED	68	-----
SATISFACTORY	55	81.0%
DEGRADED (BUT SATISFACTORY)	6	8.8%
UNSATISFACTORY	13	19.0%

LEVIED VS. MISSED FIXES

	LEVIED	MISSED	PERCENT
AVERAGE 1965-1970	507	10	2
1971	802	61	2
1972	624	126	20.2
1973	227	13	5.7
1974	358	30	8.4
1975	217	7	3.2
1976	317	11	3.5
1977	203	3	1.5
1978	290	2	0.7
1979	289	14	3
1980	213	4	1.9
1981	201	3	1.5
1982	276	17	6.2
1983	157	3	1.9
1984	210	2	1
* 1985	210	14	6.7
1986	250	10	4.0
1987	68	11	17.1

* CORRECTED DATA FOR 1985

3. AIRCRAFT RECONNAISSANCE SUMMARY

During 1987, JTWC levied requirements for 68 vortex fixes and 20 investigative missions of which only 1 was flown into a disturbance which did not develop. In addition to the levied fixes, 54 intermediate fixes were obtained. Two airborne radar fixes were provided from C-141 aircraft of opportunity missions which are not included in the statistics below. Eight synoptic track missions were requested, seven of which were completed. The synoptic tracks provide mid-level steering flow information. The average position error for the combined fixes during the 1987 season was 12 nm (22 km).

Aircraft reconnaissance effectiveness for the 1987 season is summarized in Table 2-1. The grading criteria is based on the Mission Effectiveness Grading (MEG) system which was developed and employed for the first time in 1986. This system grades the performance of each mission as satisfactory, degraded but satisfactory, unsatisfactory or missed. A mission could be degraded if certain critical weather parameters were not obtained such as temperature, dew point, minimum sea-level pressure, flight-level height in meters, etc. If the required time constraints between the primary and intermediate fixes were not met, the mission could still be deemed satisfactory but degraded.

4. SATELLITE RECONNAISSANCE SUMMARY

The Air Force provides satellite reconnaissance support to JTWC through a tropical cyclone satellite surveillance network consisting of both tactical and centralized facilities. Tactical DMSP sites monitoring DMSP, NOAA and geostationary satellite data are located at Nimitz Hill, Guam; Clark AB, Republic of the Philippines; Kadena AB, Okinawa, Japan; Osan AB, Republic of Korea; and Hickam AFB, Hawaii. These sites provide a combined coverage that includes most of JTWC's area of responsibility in the western North Pacific from near the dateline westward to the Malay Peninsula. For the remainder of its AOR, JTWC relies on the Air Force Global Weather Central (AFGWC) to provide coverage using stored satellite data. The Naval Oceanography Command Detachment, Diego Garcia, provides NOAA polar orbiting coverage in the central Indian Ocean as a supplement to this support. U.S. Navy ships equipped for direct readout also provide supplementary support.

AFGWC, located at Offutt AFB, Nebraska, is the centralized member of the tropical cyclone satellite surveillance network. In support of JTWC, AFGWC processes stored imagery from DMSP and NOAA spacecraft. Imagery recorded onboard the spacecraft as they pass over the earth is later down-linked to AFGWC via a network of command readout sites and communication satellites. This enables AFGWC to obtain the coverage necessary to fix all tropical systems of interest to JTWC. AFGWC has the primary responsibility to provide tropical cyclone surveillance over the entire Indian Ocean, southwest Pacific, and the area near the dateline. Additionally, AFGWC can be tasked to provide tropical cyclone positions in the entire western North Pacific as backup to coverage routinely available in that region.

The hub of the network is Detachment 1, First Weather Wing (Det 1, 1WW), colocated with JTWC on Nimitz Hill, Guam. Based on available satellite coverage, Det 1, 1WW is responsible for coordinating satellite reconnaissance requirements with JTWC and tasking the individual network sites for the necessary tropical cyclone fixes, intensity estimates and forecast intensities. When a particular fix is important to the development of JTWC's next tropical cyclone warning, two sites are tasked to fix the tropical cyclone from the same satellite pass. This "dual-site" concept provides the necessary redundancy to virtually guarantee JTWC an accurate satellite fix on the tropical cyclone.

The network provides JTWC with several products and services. The main service is one of monitoring its AOR for indications of tropical cyclone development. If an area exhibits the potential for development, JTWC is notified. Once JTWC issues either a Tropical Cyclone Formation Alert or warning, the network is tasked to provide three products: tropical cyclone positions, intensity estimates and forecast intensities. Each satellite tropical cyclone position is assigned a Position Code Number (PCN) to indicate the accuracy of the fix position. This is determined by the availability of visible landmarks in the image for precise gridding, and the degree of organization of the tropical cyclone's cloud system (Table 2-2).

TABLE 2-2. POSITION CODE NUMBERS (PCN)

PCN	METHOD OF CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL-DEFINED CIRCULATION CENTER/GEOGRAPHY
4	WELL-DEFINED CIRCULATION CENTER/EPHEMERIS
5	POORLY DEFINED CIRCULATION CENTER/GEOGRAPHY
6	POORLY DEFINED CIRCULATION CENTER/EPHEMERIS

During 1987, Detachment 1, First Weather Wing increased the number of estimates of the tropical cyclone's current intensity from two to four per day once a Tropical Cyclone Formation Alert or tropical cyclone warning was issued. Intensity estimates and 24-hour intensity forecasts were made using the Dvorak technique (NOAA Technical Report

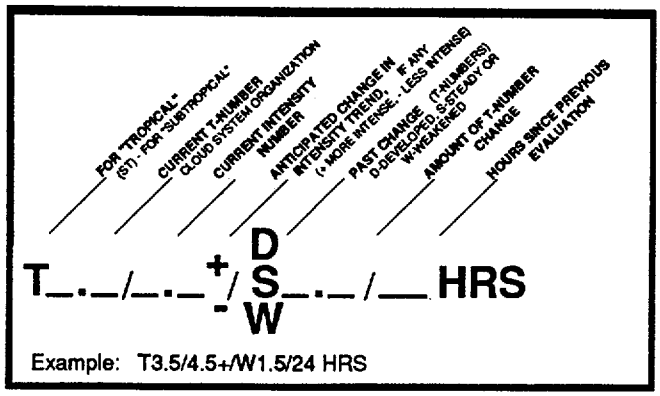
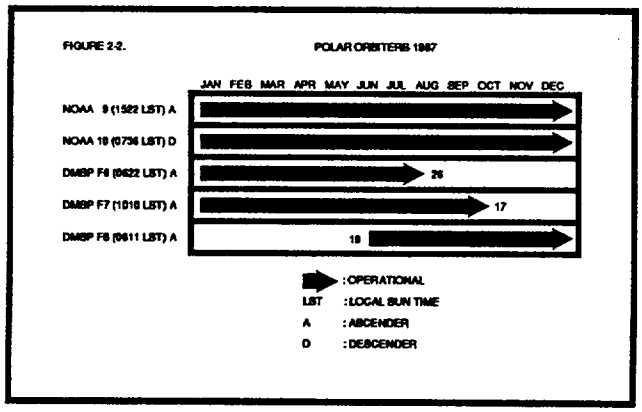


Figure 2-1. Dvorak code for communicating estimates of current and forecast intensity derived from satellite data. In the example, the current 'T-number' is 3.5, but the current intensity is 4.5 (equivalent to 77 kt (40 m/sec)). The cloud system has weakened by 1.5 'T-numbers' since the previous evaluation conducted 24-hours earlier. The plus (+) symbol indicates an expected reversal of the weakening trend or very little further weakening of the tropical cyclone during the next 24-hour period.

NESDIS 11) for both visual and enhanced infrared imagery (Figure 2-1).

Figure 2-2 shows the status of operational polar orbiting spacecraft. Three Defense Meteorological Satellite Program (DMSP) spacecraft were operational in 1987. The 19543 (F8) satellite was launched in June as a replacement for the aging 17540 (F6) spacecraft. The imaging instrument on the 18541 (F7) spacecraft failed on 17 October, which left only one DMSP spacecraft for support during the remainder of the tropical cyclone season. The special passive sensor, microwave imager (SSM/I) on the F8 spacecraft performed well until overheating forced the sensor to be temporarily shut down on 3



December. The NOAA 9 and NOAA 10 spacecraft performed well throughout the year.

On 16 August with the loss of dedicated aircraft reconnaissance, data from the satellite reconnaissance network became the primary input to warnings and best tracks in the western North Pacific. This heightened emphasis on satellite data resulted in an increase from 60 percent (in 1986) to 88 percent of warnings based on satellite.

During 1987, the satellite reconnaissance network provided JTWC with a record total of 2,835 satellite fixes on 25 tropical cyclones in the western North Pacific Ocean. In addition, 311 fixes were made on tropical cyclones in the North Indian Ocean, more than eight times the total for 1986. For the southern hemisphere, 1,192 satellite fixes were provided. A comparison of those fixes in the JTWC area of responsibility and their corresponding JTWC best track is shown in Tables 2-3A and 2-3B. (Note: Those fixes which were out-of-limits when compared with the best track are not included.)

The relationship between tropical cyclone "T-number", maximum surface wind speed and minimum sea-level pressure is outlined in Table 2-4. Table 2-5A, B and C address the verification of satellite-derived intensity estimates for developing, weakening and all cases of tropical cyclones, respectively. In each table the first column states the "T-number" in parentheses and expected current and forecast intensity. The verifying average intensities from the current and 24-hour best tracks are included to the right in the second and third columns, respectively.

5. RADAR RECONNAISSANCE SUMMARY

Fifteen of the twenty-five significant tropical cyclones in the western North Pacific during 1987 passed within range of land-based radar with sufficient cloud pattern organization to be fixed. The land-based radar fixes that were obtained and transmitted to JTWC totaled 806. Only one radar fix was obtained by reconnaissance aircraft.

TABLE 2-3A. MEAN DEVIATION (NM) OF ALL SATELLITE DERIVED TROPICAL CYCLONE POSITIONS FROM THE JTWC BEST TRACK POSITIONS IN THE WESTERN NORTH PACIFIC AND NORTH INDIAN OCEANS. NUMBER OF CASES (IN PARENTHESES).

	WESTERN NORTH PACIFIC OCEAN		NORTH INDIAN OCEAN	
	1977-1986 AVERAGE	1987	1980-1986 AVERAGE	1987
PCN	(ALL SITES)	(ALL SITES)	(ALL SITES)	(ALL SITES)
1	14.2 (1689)	14.9 (182)	16.7 (40)	20.6 (2)
2	16.3 (2118)	13.0 (511)	18.9 (7)	10.0 (2)
3	21.3 (2410)	21.4 (219)	24.1 (22)	26.0 (12)
4	23.9 (1546)	18.7 (576)	58.3 (10)	33.1 (11)
5	37.8 (4456)	32.6 (195)	36.3 (232)	44.1 (81)
6	39.5 (4222)	34.6 (1048)	44.2 (225)	36.1 (192)
1&2	15.4 (3807)	13.5 (693)	17.2 (47)	15.3 (4)
3&4	22.3 (3956)	19.5 (795)	34.8 (32)	29.4 (23)
5&6	38.6 (8678)	34.6 (1243)	40.2 (457)	38.5 (273)
TOTAL	29.3 (16441)	24.2 (2731)	37.9 (536)	37.5 (300)

TABLE 2-3B

MEAN DEVIATION (NM) OF ALL SATELLITE-DERIVED TROPICAL CYCLONE POSITIONS IN THE SOUTH PACIFIC AND SOUTH INDIAN OCEANS. NUMBER OF CASES ARE IN PARENTHESES.

	1985 - 1986 AVERAGE	1987
PCN		(ALL SITES)
1	17.6 (68)	14.5 (14)
2	15.5 (312)	17.4 (130)
3	33.7 (97)	40.4 (15)
4	27.2 (301)	26.5 (107)
5	46.8 (399)	28.8 (75)
6	38.1 (2152)	32.9 (786)
1 & 2	15.9 (380)	17.3 (144)
3 & 4	28.8 (398)	28.2 (122)
5 & 6	39.5 (2551)	32.6 (861)
TOTALS	35.5 (3329)	30.1 (1127)

TABLE 2-4. MAXIMUM SUSTAINED WIND SPEED (KT) AS A FUNCTION OF DVORAK CI & FI (CURRENT AND FORECAST INTENSITY) NUMBER AND MINIMUM SEA-LEVEL PRESSURE (MSLP)

TROPICAL CYCLONE INTENSITY NUMBER	WIND SPEED	MSLP (NW PACIFIC)
0.0	<25	----
0.5	25	----
1.0	25	----
1.5	25	----
2.0	30	1000
2.5	35	997
3.0	45	991
3.5	55	984
4.0	65	976
4.5	77	966
5.0	90	954
5.5	102	941
6.0	115	927
6.5	127	914
7.0	140	898
7.5	155	879
8.0	170	858

TABLE 2-5A. DEVELOPING STAGE

CURRENT OR FORECAST INTENSITY* (T #)	KT	VERIFYING AVERAGE BT INTENSITY KT	VERIFYING AVE 24HR BT INTENSITY KT
(0.0)	<25	---	---
(1.0)	25	22	28
(1.5)	25	25	31
(2.0)	30	30	37
(2.5)	35	35	47
(3.0)	45	47	65
(3.5)	55	57	75
(4.0)	65	65	80
(4.5)	77	75	92
(5.0)	90	88	110
(5.5)	102	102	110
(6.0)	115	115	122
(6.5)	127	127	123
(7.0)	140	138	115
(7.5)	155	---	---
(8.0)	170	---	---

* DVORAK, 1984

TABLE 2-5B. WEAKENING STAGE

CURRENT OR FORECAST INTENSITY* (T #)	KT	VERIFYING AVERAGE BT INTENSITY KT	VERIFYING AVE 24HR BT INTENSITY KT
(0.0)	<25	---	---
(1.0)	25	19	14
(1.5)	25	27	22
(2.0)	30	30	24
(2.5)	35	38	30
(3.0)	45	43	31
(3.5)	55	57	40
(4.0)	65	65	50
(4.5)	77	77	53
(5.0)	90	88	70
(5.5)	102	98	75
(6.0)	115	113	90
(6.5)	127	123	108
(7.0)	140	133	114
(7.5)	155	---	---
(8.0)	170	---	---

* DVORAK, 1984

TABLE 2-5C. ALL CASES

CURRENT OR FORECAST INTENSITY* (T #)	KT	VERIFYING AVERAGE BT INTENSITY KT	VERIFYING AVE 24HR BT INTENSITY KT
(0.0)	<25	---	---
(1.0)	25	22	26
(1.5)	25	25	29
(2.0)	30	29	33
(2.5)	35	36	41
(3.0)	45	46	55
(3.5)	55	57	59
(4.0)	65	65	65
(4.5)	77	76	76
(5.0)	90	88	88
(5.5)	102	99	88
(6.0)	115	114	101
(6.5)	127	125	114
(7.0)	140	135	114
(7.5)	155	---	---
(8.0)	170	---	---

* DVORAK, 1984

The WMO radar code defines three categories of accuracy: good (within 10 km (5 nm)), fair (within 10-30 km (5-16 nm)), and poor (within 30-50 km (16-27 nm)). Of the 807 radar fixes coded in this manner; 309 were good, 190 were fair, and 308 were poor. Compared to JTWC's best track, the mean vector deviation for land-based radar sites was 19 nm (35 km). Excellent support through timely and accurate radar fix positioning allowed JTWC to track and forecast tropical cyclone movement through even the most difficult erratic tracks.

6. TROPICAL CYCLONE FIX DATA

As in previous years, no radar reports were received on North Indian Ocean tropical cyclones.

A total of 3,754 fixes on twenty-five western North Pacific tropical cyclones and 311 fixes on eight North Indian Ocean tropical cyclones were received at JTWC. Table 2-6A, Fix Platform Summary, delineates the number of fixes per platform for each individual tropical cyclone. Season totals and percentages are also indicated. (Table 2-6B provides the same information for the South Pacific and South Indian Oceans.)

TABLE 2-6A. FIX PLATFORM SUMMARY FOR 1987

WESTERN NORTH PACIFIC	AIRCRAFT	SATELLITE	RADAR	SYNOPTIC	TOTAL
TY ORCHID (01W)	17	100	0	0	117
TS PERCY (02W)	4	60	0	0	64
TS RUTH (03W)	0	41	20	0	61
TS SPERRY (04W)	12	82	8	0	102
STY THELMA (05W)	24	141	72	0	237
TS VERNON (06W)	11	97	27	0	135
TY WYNNE (07W)	21	198	41	0	260
TY ALEX (08W)	1	100	77	0	178
STY BETTY (09W)	13	144	71	0	228
TY CARY (10W)	9	181	72	0	262
STY DINAH (11W)	0	159	106	0	265
TS ED (12W)	0	68	0	0	68
TY FREDA (13W)	0	176	29	0	205
TY GERALD (14W)	0	119	81	0	200
STY HOLLY (15W)	0	151	0	0	151
TY IAN (16W)	0	138	5	0	143
TD 17W (17W)	0	30	0	0	30
TY PEKE (02C)	0	131	0	0	131
TS JUNE (18W)	0	43	0	0	43
TY KELLY (19W)	0	111	63	0	174
STY LYNN (20W)	0	159	56	0	215
TS MAURY (21W)	0	95	0	0	95
STY NINA (22W)	0	176	79	0	255
TS OGDEN (23W)	0	17	0	0	17
TY PHYLLIS (24W)	0	118	0	0	118
TOTALS	112	2835	807	0	3754
% OF TOTAL NR OF FIXES	3.0%	75.5%	21.5%	0.0%	100.0%

NORTH INDIAN OCEAN	SATELLITE	SYNOPTIC	TOTALS
TC 01B	59	0	59
TC 02B	59	0	59
TC 03A	38	0	38
TC 04B	15	0	15
TC 05B	43	0	43
TC 06B	32	0	32
TC 07A	16	0	16
TC 08B	49	0	49
TOTALS	311	0	311
% OF TOTAL NR OF FIXES	100.0%	0.0%	100.0%

TABLE 2-6B. FIX PLATFORM SUMMARY FOR 1987

THE SOUTH PACIFIC AND SOUTH INDIAN OCEANS	SATELLITE	RADAR	SYNOPTIC	TOTAL
TC 01S --------	21	0	0	21
TC 02P OSEA	59	0	0	59
TC 03P PATSY	69	0	0	69
TC 04P RAJA	113	0	0	113
TC 05P SALLY	32	0	0	32
TC 06S --------	26	0	0	26
TC 07S --------	45	0	0	45
TC 08P TUSI	21	0	0	21
TC 09S ALININA	39	0	0	39
TC 10S CONNIE	55	0	0	55
TC 11P IRMA	32	0	0	32
TC 12S DAMIEN	59	0	0	59
TC 13P --------	8	0	0	8*
TC 14P UMA	34	0	0	34
TC 15P JASON	67	0	0	67
TC 16P VELI	10	0	0	10
TC 17S CLOTILDA	21	0	0	21
TC 18S ELSIE	53	0	1	54
TC 19P --------	1	0	0	1*
TC 20P WINI	21	0	0	21
TC 21S DAODO	71	0	0	71
TC 22P YALI	58	0	0	58
TC 23P KAY	118	0	0	118
TC 24S --------	29	0	0	29
TC 25P ZUMAN	15	0	0	15
TC 26S --------	20	0	0	20
TC 27P BLANCHE	70	0	0	70
TC 28S --------	25	0	0	25
TOTAL	1192	0	1	1193
# OF TOTAL NR OF FIXES	99.9%	0.0%	0.1%	100.0%

* Incomplete data set